ABSTRACT: Modeling of CO_2 Saline Aquifer Sequestration and the Effects of Residual Phase Saturation

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Petrophysical properties have a strong influence on how a plume of injected CO_2 will form and move in the subsurface. Permeability controls the direction and rate of CO_2 movement, and porosity and residual saturation control the size, shape, and dispersion. This research simulates the movement of sequestered CO_2 taking into account the effects of residual non-wetting phase saturation To examine CO_2 plume characteristics, petrophysical analysis was accompanied by 3D geocellular modeling as an input into fluid-flow simulator. Petrophysical algorithms were developed that captured the interrelationships amoung porosity, horizontal and vertical permeability, residual CO_2 saturation and wireline logs. These petrophysical algorithms were applied to develop a 3D geocellular aquifer model based on sandstone-body geometry. The resultant model was used to simulate CO_2 injection in a saline aquifer. Two base cases using constant low or high residual CO_2 saturation were compared with an algorithm employing variable residual saturation. In the latter model, the residual CO_2 saturation of each grid block depended on the initial CO_2 saturation of the grid block, resulting in hysteretic relative permeability and capillary pressure curves. During injection, the CO2 plume was roughly radially symmetric, with permeability variability, depth, and buoyancy affects combining to create a tornado-shaped plume. During the post-injection period, the initial tornado-shaped plume is distorted by permeability variation, dip direction and residual saturation. Much greater dispersion of the CO2 plume occurred when residual CO2 saturation was low. Residual non-wetting phase saturation therefore is a key factor controlling long term sequestration.